

ARTICLE

Adolescents' face mask usage and contact transmission in novel Coronavirus

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Abstract

The global outbreak of coronavirus has become an international public health threat. Prevention is of paramount importance to contain its spread. This study observes face mask wearing behavior and contact transmission problems in Taiwan. Teachers track student status in class. In addition to measuring body temperature and regular disinfection, classrooms require ventilation wear mask, provide alcohol spray and avoid sharing the microphone. Both questionnaire surveys and experimental were utilized. A total of 160 adults residing in Taiwan participated in the survey. The dye simulated the possible virus area on the mask surface during usage. Subjects were required to complete a questionnaire and simulate the spread of contact transmission when using a computer. Eighty-one % of respondents reported consistent use of surgical masks several times a day. They reported taking their masks off in relatively safe areas. Most people reported using one mask per day and storing the masks in their pockets. As a result, masks surface become a contamination source. In the contact experiment, ten adults were requested to don and doff a surgical mask while doing a word processing task. The extended contamination areas were recorded and identified by image analysis. The results show an average contamination area of the workspace is significant 530 cm². When the hand touches the surface of the mask, it may spread the virus to the subsequent contact area.

Introduction

The World Health Organization (WHO) is charged with curbing the spread of diseases with public health concerns.¹ However, health promotion programs often based on narrowly conceived conceptual models. As reported by Stokols² compares three distinct theoretical perspectives on health promotion: behavioral change, environmental enhancement, and social ecological models. Health promotion programs enhance societal relationships. Multidisciplinary perspectives focus and promote interventions on high-impact behaviors. Ho³ analyzed the effect of close contact on the spread of Severe Acute Respiratory Syndrome (SARS) and found that contact transmission can be limited through behavioral change.

New Coronavirus

On Jan 7, 2020, a novel Coronavirus was identified by the Chinese Center for Disease Control and Prevention (CDCP) from the throat swab sample of a patient and was subsequently named 2019-nCoV.⁴ The disease was of cluster onset, resulting in severe and even fatal infections. A lower respiratory tract predilection suggested that airborne transmission was possible.⁵ In comparison, SARS was transmitted by droplet, contact and airborne spread, including ventilation pipes between building floors.

Among the general public in China and other countries, the transmissibility of the epidemic might be reduced because of community-wide social distancing measures as reported by Wu.⁶ Studies suggested that "hand hygiene and facemasks seemed to prevent household transmission of influenza virus and the non-pharmaceutical interventions are important for mitigation of pandemic".⁷

Investigation on spatiotemporal transmission patterns and intervention strategies are warranted. Integrated interventions, such as the promotion of face mask use and reduction of travel, have been actively implemented. Studies suggest that additional 10% decay in the transmission rate would reduce the peak infected population size by 20-47% as reported by Shen.⁸ Experts suggest that people stay at home and use masks for personal protection as reported by Kickbusch.⁹ Public health policy officials recommend that at least 70% of the population comply with face mask usage to avoid the breakdown of the healthcare system.¹⁰

The worldwide spread of SARS proceeded with rapidity, overwhelming many hospitals and public health systems. Among infected cases of SARS reported worldwide, about 17% to 30% were aged 50 or older.¹¹ In many locations, the disease spread to health care workers and household contacts. Many infectious diseases spread through populations via the networks formed by physical contacts among individuals. The patterns of these contacts tend to be highly heterogeneous and illustrate the utility for assessing public health strategies as reported by Meyer.¹² Hospitals remind people to wear face masks at worksites and in public places. Health care professionals also promote face mask usage to individuals in public areas to prevent spreading disease.¹³ A case-control study was conducted in five Hong Kong hospitals with 241 non-infected and 13 infected staff during patient care.¹⁴ All participants were surveyed about the use of mask, gloves, gowns,

Significance for public health

The epidemic has caused pressure to prevent in most countries. Through the school's auxiliary measures, students attended classes during March-June 2020 in Taiwan. Maintaining social distance and wearing masks are important ways to reduce the spread. Inadvertent hand contact with the outer surface of the mask may also cause the virus to spread indirectly. Students' "mask use behavior survey" shows that a single mask has been used repeatedly for a long time. Emulation experiment demonstrated the potential of contact among office area. Masks must be used attentively to reduce the chance of indirect transmission.

and hand-washing as recommended under droplet and contact precautions. Practice of droplet and contact precaution was found to be adequate in reducing the risk of infection.

The Health Belief Model has been proposed as a means of understanding an individual's volitional health behaviors. During the SARS epidemic, Wong *et al.*¹ found that only 54.8% of Chinese adolescents practiced recommended habitual behaviors for preventing the spread of the disease. There was a significant correlation between perceiving a significant threat and compliance with habitual behaviors.

Face mask and risk of infection

Through the school's regulation and auxiliary measures, Taiwan's students still attended classes till June 2020. After the identification of 2019-nCoV, Taiwanese health authorities stepped up various prevention and intervention activities against the further spreading. Schools and universities were suspended for prompt isolation of infected individuals in February 2020. Quarantined individuals were required to wear surgical masks whenever they enter a communal area. At the individual level, suggested preventative behaviors included: i) maintaining good personal hygiene, ii) developing a healthy lifestyle with proper diet, regular exercise, and adequate rest, iii) ensuring adequate ventilation at home and in the office, and iv) wearing masks, especially for those with pre-existing respiratory tract infections. People are warned to avoid close contact and the duration of time that the virus can survive on the surface of an object. Contact tracking and family isolation were arranged to strengthen control. According to the literature, perceived susceptibility, perceived severity, and action cues are important predictors of wearing a mask. In this study, we investigated both young people's mask usage behavior and simulated experiment with possible contact area spreading.

Surgical masks are intended to protect the patient from the surgeon during surgery. FFP2 masks are intended to protect the user.¹⁵ The outermost covering is an isolation layer intended to block larger dust particles. The second layer has a filter which removes fine dust and bacterium in the air. The outside of the mask is considered a contaminated area and should not be touched with the hands. When pulling the elastic band backward to remove the mask, the

user needs to grasp the strap of the mask to avoid contact. The gap of the mask must be small, and it should be replaced after cumulative use. "Masks are found to be useful with respect to both preventing illness in healthy persons and preventing asymptomatic transmission". "Even very weak masks can still be useful."¹⁶

The Centers for Disease Control and Prevention developed recommendations for respirators worn to minimize exposures to *Mycobacterium tuberculosis*.¹⁷ Handling may increase the risk of infection if loaded organisms remain viable. Li¹⁸ assessed the antimicrobial activity of nanoparticles and nanoparticle-coated face masks to protect against infectious agents. Nanoparticles have shown promise when applied as a coating to the surface of protective clothing in reducing the risk of transmission of infectious agents. Lin *et al.*¹⁹ sought a method for recovering loaded bacteria from filtering respirators and investigated the effects of artificial saliva (AS) and artificial perspiration (AP) on the filter performance. AP was especially effective in N95 masks and AS was especially effective in surgical masks.

Indirect contact infection caused by re-contact with hands should also be considered. For example, the chance of infection increases if medical personnel make contact with patients but do not disinfect their hands after adjusting their masks. People who wear masks may nevertheless be exposed to infection during drinking. Donning and doffing a mask will also increase the chance of infection.

Method

Both questionnaire surveys and experimental were utilized. The survey can understand the user's thoughts and expectations, and the experiment can observe the usage behavior and contact area.

Survey items

Data for this study was obtained using a questionnaire survey of young adults aged 18-21 residing in Taiwan. University students from four different departments took part in the survey (n=160). Respondents were asked to indicate on a 5-point scale the degree to which they agreed that wearing face masks could induce problem or inconvenience (1 indicating "strongly disagree," 5 indicat-

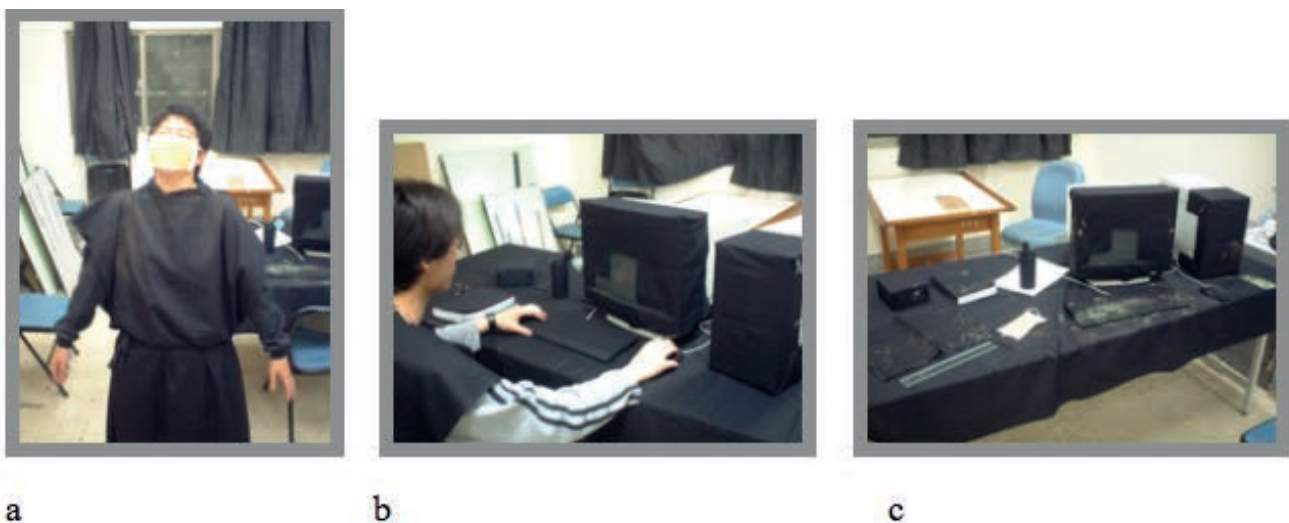


Figure 1. Experimental site and records: a) subject after the test; b) execution of tasks in the test area; c) the contaminated test site.

ing “strongly agree”). High scores indicated that respondents perceived significant problems or inconvenience in wearing face masks. Five main problems of wearing face masks were listed: 1) discomfort with inhaling and exhaling, 2) excessive warmth and humidity, 3) unpleasant odor, 4) inconvenience with donning and doffing, and 5) tendency for glasses to fog up.

- 1) What kinds of masks do you prefer?
- 2) How many masks do you use per day?
- 3) How many hours per day do you use a surgical mask?
- 4) Where do you store your mask when you remove it?

Contact experiment procedure

This experiment intended to observe potential contact transmission spread to other surfaces during mask usage. The face mask's outer surface is a potential contamination source. In this contact area experiment, 10 adults were requested to don and doff a face mask while performing an office task. The contact areas associated with face mask handling were recorded by a camera. Different colors of dye were placed on the outer surface of a face mask. The dye simulated the possible virus area on the mask surface during usage. Contacting this area by hand or other parts of the body extended the contact area. Participants' behavior while wearing face masks was recorded and image analysis was utilized to identify the extended contact area.

Experiments were performed in a preset environment with a computer and assorted stationery on the desk (Figure 1). Subjects were required to complete a questionnaire and simulate the spread of contact transmission when using a computer. The equipment the subjects touched included the computer tower, keyboard, mouse, screen, desktop, and assorted stationery. The researcher prepared powder toner (10 colors, one color for each subject), a face mask with powder coating, a 28-foot length of thin black cloth used to cover the workstation, and camera. The experimental procedure

was as follows:

- 1) Each subject donned a mask (the outer side of which was stained with toner and entered the experimental area.
- 2) The subject was instructed to take off their jacket and mask.
- 3) The subject filled out the designated questionnaire within 5 minutes and without leaving their seat.
- 4) The subject was instructed to turn off the computer, don their mask, and leave.

After all subjects had participated, pictures were then taken of the contaminated area and the black cloth was cleaned of powder. Rhino software was used to remove the black background in each photo to calculate the contaminated area.

Results

Survey results

Behavioral surveys were collected and analyzed with SPSS. The results were selected for discussion below. The average total use time of mask was 5.306 hours. 63.8% of respondents said that they donned and doffed their masks several times because of work. Masks were usually placed in the following locations: bags (60%), jacket pockets (17%), pants pockets, (15%), and desk surfaces (8%). Masks that were carried around had a risk of indirect contamination. Regarding the feeling of using the mask, the mean value of inconvenience of inhalation was 3.487, the average value of excessive warmth and humidity was 4.025, and the mean of inconvenience with donning and doffing the mask was 3.168. A high degree of agreement indicated that maintaining smooth breathing was a major problem when wearing a face mask. Table 1 shows the mean scores and standard deviation values for those statements.

There was a statistically significant positive relationship between participants feeling too hot and feeling discomfort with breathing and foggy glasses. The high mean scores ranged from 3.168 to 4.025 and the correlation coefficient values ranged from 0.426 to 0.387 (** $p < 0.01$). The inconvenience of inhalation was significantly related to the feeling of excessive heat (Pearson correlation coefficient γ is 0.426, $p = 0.000$). This data reflects the feeling that the structure and use of the face mask could be improved.

The mean value of unpleasant odor was 3.462, and that of glasses fogging up was 3.918. The distribution was skewed right and the maximum reported value was 5. A high degree of consensus indicated that respondents were concerned that face masks are vented upwards, which might infect their eyes. This might affect the mask's effectiveness in preventing disease transmission.

Experiment results

The experimental environment and process are shown in Figure 1. After each test, a researcher took four photos of the subject (body front, back, left, and right). In addition, photographs of the contaminated locations on workspace were also taken. Figure 2 shows that the contamination area varied with different users. The average contaminated area of the ten subjects was 530 cm², with the maximum contamination area reaching three times that of the minimum.

Conclusions

Although surgical masks are considered a viable means of protecting individuals from disease during an epidemic, accidental

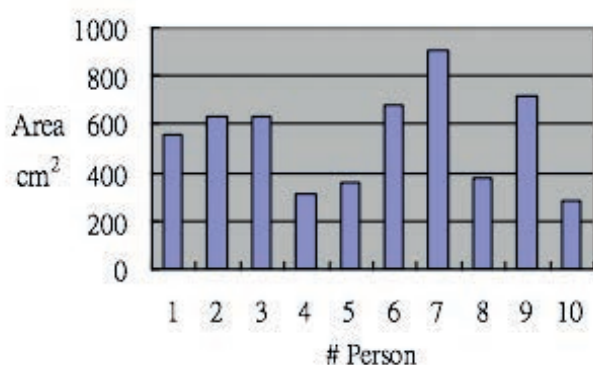


Figure 2. Operating contaminated area of each tested individual.

Table 1. Participants' views on mask use and feel.

Statement	Mean	SD
Hours of use per day	5.306	2.2261
Discomfort with inhaling	3.487	0.9382
Excessive warmth and humidity	4.025	1.0397
Unpleasant odor	3.462	0.8964
Inconvenience with donning	3.168	0.9195
Tendency for glasses to fog up	3.918	1.1761

transmission through direct and indirect contact still puts face mask users at risk of infection. The survey of mask usage revealed the usage per day during an epidemic prevention period was 5.306 hours. Because most people repeatedly donned and doffed their masks, there was a high possibility of pollution during use. During the experiment, the subjects often had no specific place to store their masks, so they often stored the masks in their pockets, which might cause indirect contact transmission of pathogens. The average inconvenience of mask inhalation is high; and the mean value of hot and sultry is 4.025. A high degree of the agreement indicates that the smoothness of breathing is troublesome. The contact spread experiments show that the contaminated area varies considerably from user to user. The average polluted area of the ten subjects was 530 cm². Hand contact is one of the transmission paths; when the hand touches the surface of the mask, it may spread the virus to the subsequent contact area, which is worthy of attention for general users.

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